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NATIONAL DAM SAFETY PROGRAM. STEPHENS LAKE DAM, (MO 11172), MIS--ETC(U)
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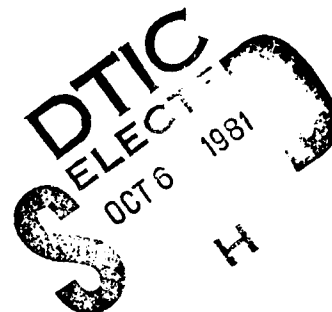
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BOONE COUNTY, MISSOURI
MO. 11172



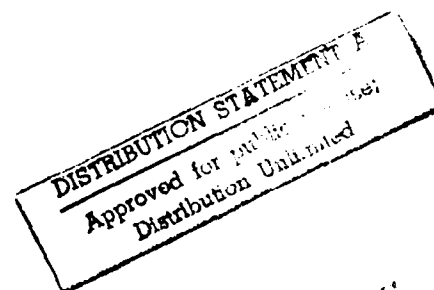
**PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM**



**United States Army
Corps of Engineers**

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PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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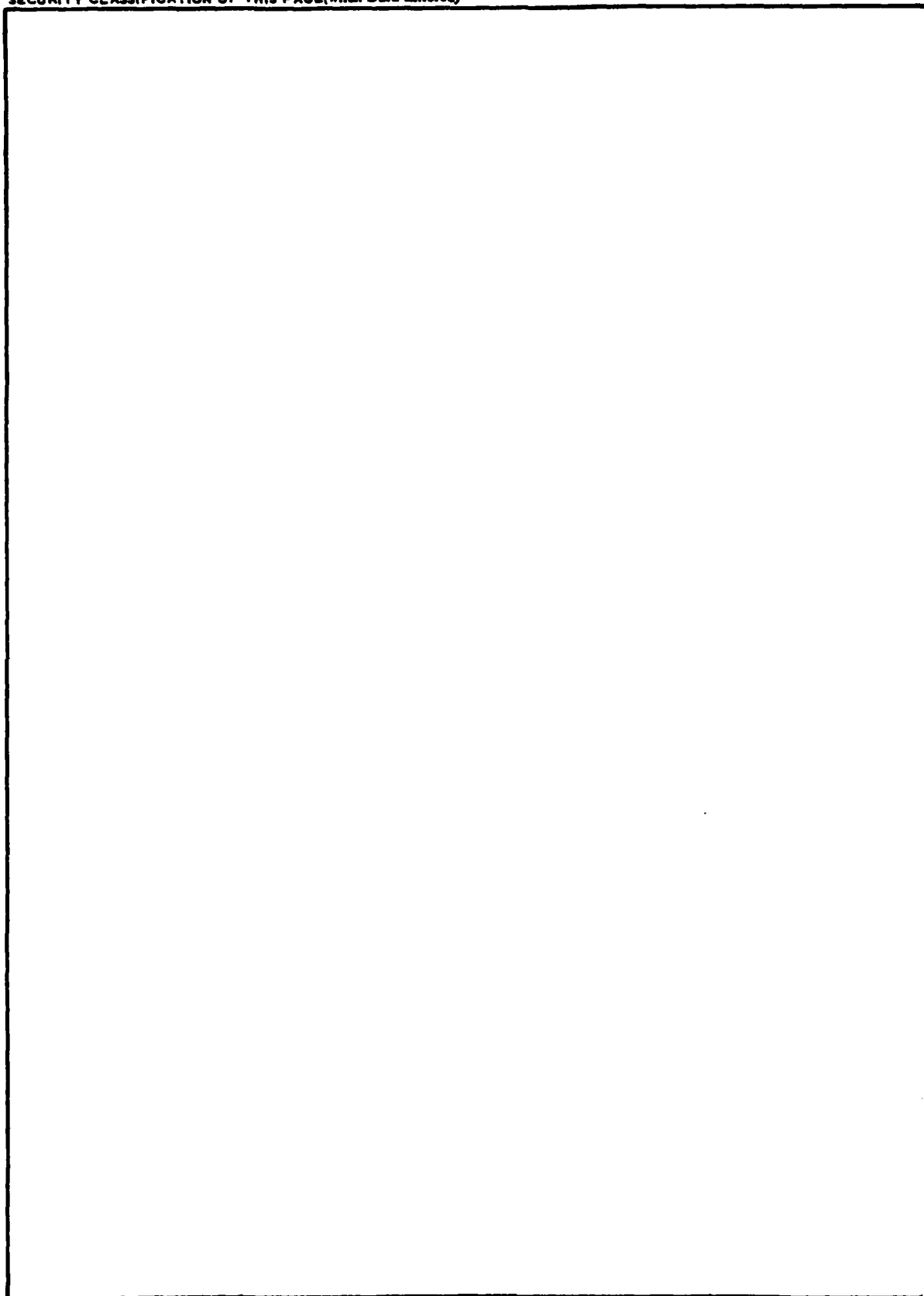
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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Stephens Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Stephens Lake Dam (MO 11172).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

SIGNED

Chief, Engineering Division

24 FEB 1981

Date

APPROVED BY:

SIGNED

Colonel, CE, District Engineer

25 FEB 1981

Date

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STEPHENS LAKE DAM
BOONE COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11172

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
CONSOER, TOWNSEND AND ASSOCIATES, LTD.
ST. LOUIS, MISSOURI
AND
PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO
A JOINT VENTURE

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

DECEMBER 1980

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Stephens Lake Dam, Missouri Inv. No. 11172
State Located: Missouri
County Located: Boone
Stream: An unnamed tributary of Hinkson Creek
Date of Inspection: July 11, 1980

Assessment of General Condition

Stephens Lake Dam was inspected by the engineering firms of Consoer, Townsend and Associates, Ltd. and PRC Engineering Consultants, Inc. (A Joint Venture) of St. Louis, Missouri according to the U. S. Army Corps of Engineers' "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District of the Corps of Engineers. Based upon the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. Within the estimated damage zone of four miles downstream of the dam, there are thirteen dwellings, one shopping center, apartment houses, and a trailer court which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Stephens Lake Dam is in the small size classification since it is 23 feet high, and impounds more than 50 acre-feet but less than 1,000 acre-feet of water.

The inspection and evaluation of the consultant's inspection team indicate that the spillway of Stephens Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Stephens Lake Dam being a small size dam with a high hazard potential is required by the guidelines to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping. Considering the large number of inhabited dwellings located downstream of the dam, the PMF is considered the appropriate spillway design flood for Stephens Lake Dam. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. It was determined that the reservoir/spillway system can accommodate approximately ⁴⁵/~~50~~ percent of the Probable Maximum Flood without overtopping the dam. Our evaluation also indicates that the reservoir/spillway system can accommodate the one-percent chance flood (100-year flood) without overtopping.

Stephens Lake Dam and its appurtenant structures appear to be in fair condition due to what appears to be the possibility of past piping of the embankment material along the spillway pipe. This condition is considered to be a significant deficiency and has already caused some damage to the spillway and the dam embankment.

Other deficiencies noted by the inspection team were: the erosion due to wave action on the upstream slope, rodent holes in the embankment, the small shrubs growing in the wave eroded area, a need for periodic inspection by a qualified engineer and a lack of maintenance schedule. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.



A handwritten signature in cursive script, reading "Walter G. Shifrin".

Walter G. Shifrin, P.E.



Overview of Stephens Lake Dam

NATIONAL DAM SAFETY PROGRAM

STEPHENS LAKE DAM, I.D. No. 11172

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

STEPHENS LAKE DAM, Missouri Inv. No. 11172

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Stephens Lake Dam was carried out under Contract DACW 43-80-C-0094 between the Department of the Army, St. Louis District, Corps of Engineers, and the engineering firms of Consoer, Townsend & Associates, Ltd., and PRC Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. Purpose of Inspection

The visual inspection of Stephens Lake Dam was made on July 11, 1980. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project, presents a summary of visual observations made during the field inspection, presents an assessment of hydrologic and hydraulic conditions at the site, and the structural adequacy of

the various project features and assesses the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted that in this report reference to left or right abutments is viewed as looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to the north abutment or side, and right abutment or right side to the southwest abutment or side.

d. Evaluation Criteria

The inspection and evaluation of the dam is performed in accordance with the U.S. Army Corps of Engineers' "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District office of the Corps of Engineers for Phase I Dam Inspection.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The following description is based upon observations and measurements made during the visual inspection and from conversations with Mr. Marion Henley, Director of Buildings and Grounds for Stephens College. No design drawings were available for this dam or appurtenant structures.

The dam is a compacted earthfill structure between earth abutments. The measured top width is 14 feet and the length along the axis is 648 feet. A plan and elevation of the dam are shown on Plate 2 and Photos 1 through 3 show views of the dam. The alignment

of the dam is generally straight along the middle 400 feet of the embankment with an average curvature in the upstream direction of 15 degrees in the last 100 feet on each extreme of the dam. The top of dam has a minimum elevation of 691.3 feet above mean sea level (M.S.L.) which occurs at about the left 1/3 point and the maximum structural height of the embankment which occurs at approximately the right 1/3 point was measured to be 23 feet. At the location of the minimum top of dam elevation, the top of dam slopes upward to each abutment with a rise in elevation of 1 foot. The top of dam is used as an access road for light maintenance equipment.

The downstream slope of the embankment was measured to be 1V on 2.25H. It was not possible to accurately measure the upstream slope because of wave erosion on the face and a near horizontal, riprapped bench at the water surface. However, the measurements made over the short unaltered upstream slope indicated the upstream slope to be 1V to 1.5H. Except for the riprapped bench and wave eroded face of the upstream slope, the entire exposed embankment is protected by a dense short grass cover.

There is only one spillway at the damsite which consists of a concrete side channel connected to a vitrified clay pipe which passes through the embankment. The side channel structure consists of a rectangular shaped concrete box which is 10.6-feet long, 2.5-feet wide and 2.5-feet deep (see Photo 5). The control section of the channel is located on the south side of the box and has an assumed crest elevation of 689.0 feet above M.S.L., which places the crest 6 inches below the top of the rest of the structure. The clay pipe is 24 inches in diameter and about 37 feet long. The pipe is laid through the embankment on a 10 percent grade. A 6-inch high, wood framed structure with a wire screen was provided at the entrance to the side channel as a fish screen. The spillway is located approximately 38 feet to the right of the left abutment/embankment contact.

A 4-inch diameter siphon pipe was provided at the damsite to drain the reservoir if needed. The siphon consists of a 4-inch steel pipe which is controlled by a 4-inch gate valve located on the upstream side of the system (see Photo 9). According to Mr. Henley, the siphon was last used in 1955 to lower the reservoir. The siphon is located about 150 feet to the right of the left abutment.

An electric powered, vertical submersible centrifugal turbine pump was installed at the damsite (see Photo 10). The purpose of the pump is to pump groundwater into the reservoir to help keep the reservoir at a desired level. The pumphouse is located on the right side of the reservoir.

b. Location

Stephens Lake Dam is located in Boone County in the State of Missouri, and crosses an unnamed tributary of Hinkson Creek. The dam is located on the east edge of the City of Columbia. The Stephens Lake Dam location on the 7.5 minute series of the U.S. Geological Survey maps is found in Section 7 of Township 48 North, Range 12 West, of the Columbia, Missouri Quadrangle Sheet.

c. Size Classification

The impoundment of Stephens Lake Dam is less than 1,000 acre-feet but more than 50-acre feet, and its height is 23 feet. Therefore, the size is determined to fall in the "small" category, according to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief Engineer.

d. Hazard Classification

The dam has been classified as having a "high" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. The findings of the consultant's inspection team concur with this classification. There are thirteen dwellings, apartment houses, a shopping center and a trailer court within the estimated damage zone, extending four miles downstream of the dam.

e. Ownership

Stephens Lake Dam is owned by Stephens College of Columbia, Missouri. All correspondence is directed to Mr. Marion Henley, Director of Buildings and Grounds, Stephens College. The mailing address is as follows: 1200 East Broadway, Columbia, Missouri, 65215.

f. Purpose of Dam

At present the Stephens Lake is used only for recreation. However, originally the lake was built for stock watering purposes. At that time, according to Mr. Henley, the impoundment was much smaller than the present impoundment.

g. Design and Construction History

The information on the design and construction of the dam, as described below, was given to the inspection team by Mr. Henley. The original dam was built around the turn of the century for stock watering purposes. The original dam and lake were much smaller than the present dam and lake. Stephens College purchased the property in the late 1920's and the lake was enlarged in 1939 by increasing the size of the dam. Since the watershed area was not

sufficient to support the enlarged lake, a deep well was also drilled at the same time and a pump installed to pump water into the reservoir to help keep the reservoir at a desired level. The lake and dam were probably constructed without any engineering design and supervision. The lake level was lowered in 1955 and a larger swimming area was blasted out of the bedrock on the south rim of the reservoir. The spillway was also constructed at this time.

h. Normal Operational Procedures

Normal procedures is to allow the reservoir to remain as full as possible with the water level being controlled by rainfall, runoff, evaporation, the elevation of the spillway crest, and periodic supply of groundwater from the well near the lake.

1.3 Pertinent Data

a. Drainage Area (acres): 38

b. Discharge at Damsite

Estimated experienced maximum flood (cfs): 4

Estimated ungated spillway capacity with
reservoir at top of dam elevation (cfs): 42

c. Elevation (Feet above MSL)

Top of dam (minimum): 691.3

Spillway crest*: 689

Normal Pool: 689

Maximum Experienced Pool: 689.25

Observed Pool: 688.3

d. Reservoir

Length of pool with water surface
at top of dam elevation (feet): 1100

e. Storage (Acre-Feet)

Top of dam (minimum): 89

Spillway crest: 63

Normal Pool: 63

Maximum Experienced Pool: 65.5

Observed Pool: 55

f. Reservoir Surfaces (Acres)

Top of dam (minimum): 12

Spillway crest: 10

Normal Pool: 10

Maximum Experienced Pool: 10.3

Observed Pool: 9.8

g. Dam

Type:	Rolled, earthfill
Length:	648 feet
Structural Height:	23 feet
Hydraulic Height**:	23 feet
Top width:	14 feet
Side slopes:	
Downstream	1V on 2.25H
Upstream	1V on 1.5H (Above the water surface)
Zoning:	Unknown
Impervious core:	Unknown
Cutoff:	Unknown
Grout curtain:	Unknown
Freeboard above	
normal reservoir level:	2.3 feet (Minimum)
Volume:	23,700 cu. yds. (Estimated)

i. Spillway

Type: Side channel and culvert
combination
Length of crest: 10.6 feet
Crest Elevation (feet above MSL): . . 689

j. Regulating Outlets

Type:	4-inch siphon (Inoperable)
Location:	150 feet to the right of the left abutment
Length:	Unknown
Closure:	4-inch gate valve
Maximum Capacity:	Unknown

* The elevation of the spillway crest is assumed from the U.S.G.S. Columbia, Missouri Quadrangle topographic map. The elevation of other features of the dam are obtained by using this elevations and field measurements.

** The hydraulic height of the dam is the vertical distance from the lowest point on the downstream toe to the top of dam or the maximum water surface, if below the top of dam.

SECTION 2: ENGINEERING DATA

2.1 Design

No design data are available for the dam and appurtenant structures. Mr. Henley of Stephens College did provide a one sheet survey plan showing contour lines and elevations which was drawn about 1930 by W. B. Cauthorn, a local engineer. He also made available a "Pump Installation Report" dated May 10, 1963 which lists the characteristics of the pump and well.

2.2 Construction

No construction records or data are available for Stephens Lake Dam.

2.3 Operation

No operational records are available for Stephens Lake Dam.

2.4 Evaluation

a. Availability

No design drawings, design computations, construction data, or operation data are available. Also, no pertinent data were available for review of hydrology, spillway capacity, flood routing through the reservoir, outlet capacity, slope stability, or foundation conditions. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy

The lack of engineering data did not allow a definitive review and evaluation. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing and evaluating design, operation and construction data, but is based primarily on visual inspection, past performance history, and sound engineering judgment.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity

No valid engineering data relating to the design and construction of the dam are available for Stephens Lake Dam.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Stephens Lake Dam was made on July 11, 1980. The following persons were present during the inspection:

<u>Name</u>	<u>Affiliation</u>	<u>Disciplines</u>
Dr. M.A. Samad	PRC Engineering Consultants, Inc.	Project Engineer, Hydraulics and Hydrology
Mark Haynes, P.E.	PRC Engineering Consultants, Inc.	Civil and Mechanical
Razi Quraishi, R.P.G.	PRC Engineering Consultants, Inc.	Geology
Zoran Batchko	PRC Engineering Consultants, Inc.	Soils
Kevin J. Blume	Consoer, Townsend & Assoc., Ltd.	Civil and Structural
Joe Kellett	Corps of Engineers	
Randall Dreiling	Corps of Engineers	

David Busse Corps of Engineers

Wayne Richter Corps of Engineers

Mr. Marion Henley Stephens College

Specific observations are discussed below.

b. Dam

The top and the downstream slope of the dam have a well maintained grass cover which adequately protects the embankment material against surface erosion. Rodent holes less than 1-1/2 inches in diameter were observed on the downstream slope (see Photo 4). According to Mr. Henley, the dam has never been overtopped and no evidence indicating the contrary was observed.

The upstream slope has riprap protection extending from about 2.5 feet below the top of dam to below the water surface where sloughing of the riprap is prevented by batter boards (see Photo 1). The upstream slope has been eroded by wave action. The slope of the exposed riprapped portion of the upstream slope was measured to be 5° (nearly horizontal) while the scarp due to wave action is typically 45° (1V on 1H) or steeper. The exposed eroded face is generally on the order of 18 inches high and vegetated by small shrubs. The exposed embankment material is a dark gray, moderately plastic silty clay.

There is no evidence of seepage or leakage through or below the dam, except for two large voids in the downstream face immediately adjacent to the spillway pipe (see Photo 7). These voids appear to be due to leakage along the spillway pipe, as further described in Section 3.1.d.

No signs of past or present instability were seen on the embankment except for the wave eroded upstream slope near the crest.

Both abutments slope gently upward from the top of dam. No instabilities, seepage, or erosion were observed on either abutment.

c. Project Geology and Soils

(1) Project Geology

The damsite is located on an unnamed tributary of Hinkson Creek in the Dissected Till Plains Section of the central Lowland Physiographic Province. Loess-mantled Kansas Drift covers the surface of most of the Dissected Till Plains Section. This section is distinguished from the Young Drift Section to the north and from the Till Plains on the east by the stage it has reached in the post-glacial erosion cycle. Broadly generalized, this section is a nearly flat till plain submature to mature in its erosion cycle.

The topography at the damsite is rolling to hilly with gentle slopes. Elevations of the ground surface range from 690 feet above M.S.L. at the damsite to 750 feet above M.S.L. approximately 0.5 mile from the damsite. The reservoir slopes at the southern side of the reservoir are in the range of 15° to 26° from the horizontal, between 10° to 20° from the horizontal at the northern side, and in the range of 7° from horizontal at the western side. The reservoir slopes appear to be stable and free of any potential slide activity. The area near the damsite is covered with slope wash of glacial-fluvial deposits and loess.

The regional bedrock geology beneath the glacial outwash deposits in the damsite area as shown on the Geologic Map of Missouri (1979), (see Plate 3), consists of Pennsylvanian undifferentiated rocks, Pennsylvanian Marmaton-Cherokee Group (cyclic deposits of shale, limestone, and sandstone), Mississippian age Burlington

Limestone (cherty, grayish brown sandy limestone), Devonian age rocks of the Sulphur Springs Group (Glen Park Limestone and Grassy Creek Shale), and the Ordovician age rocks consisting of St. Peter Sandstone and Powell Dolomite. The predominant bedrock near the site underlying the glacial-fluvial deposits are the Marmaton-Cherokee Group rocks and the Burlington Limestone.

Outcroppings of Pennsylvanian Marmaton Group rocks consisting of slightly weathered to unweathered, whitish gray, fine to medium grained, hard limestone are exposed in a hill adjacent to the northeast rim of Stephens reservoir and at the swimming area (see Photo 11). These rocks are horizontally bedded with a rectangular jointing pattern. Inlet and outlet areas to the reservoir of the unnamed tributary of Hinkson Creek contain Quaternary alluvium.

No faults have been identified in the vicinity of the damsite. The closest trace of a fault to the damsite is the Fox Hollow fault nearly 15 miles southwest of the damsite. The Fox Hollow fault had its last movement in post-Mississippian time. Thus, the fault has no effect on the dam.

Stephens Lake Dam consists of an earthfill embankment (dark gray to brown silty clay), with a side channel/clay pipe combination spillway located near the left abutment. Based on the available data, conversations with Mr. Marion Henley and the visual inspection, the embankment rests on the Pennsylvanian Marmaton Group rock consisting of unweathered whitish gray, fine to medium grained, hard limestone. The entire spillway system rests on the compacted embankment fill.

(2) Project Soils

According to the "Missouri General Soil Map and Soil Association Description" published by the Soil Conservation Service, the materials in the general area of the dam belong to the soil series of Sharpsburg-Pole-Sogn-Snead in the Deep Loess and Drift

family. The soils were basically formed from loess and the weathering of calcareous clay shale and limestone. The permeability of these soils ranges from moderate to slow.

Materials were removed from below the vegetative cover on the downstream and upstream embankment slopes. The material removed from the embankment near the left abutment and representative of the left most 20 feet of the embankment appeared to be a yellowish brown, low plasticity sandy clay. Based upon the Unified Soil Classification System, the soil would probably be classified as a CL. This soil type generally has the following characteristics: semipervious with a coefficient of permeability less than 500 feet per year, medium to high shear strength, and a low to intermediate resistance to piping. The materials removed from and representative of the remainder of the embankment appeared to be a dark gray silty clay with a trace of fine to coarse sand. Based upon the Unified Soil classification System, the soil would probably be classified as a CL. This soil type generally has the following characteristics: impervious with a coefficient of permeability less than 100 feet per year, medium to high shear strength and an intermediate resistance to piping.

d. Appurtenant Structures

(1) Spillway

The side channel structure appeared to be stable with no major problems apparent. However, some minor leaching and cracking of the concrete was observed. The stability of the clay pipe appeared to be in jeopardy. It appears that water from the upstream end has been flowing along the outside of the pipe and has carried embankment material along with it. Two large holes to the right of the outlet of the pipe (see Photo 7), a small depression on the downstream slope over the pipe and several cracks on the upstream slope over the pipe were observed which indicates the possibility that past piping of the embankment material along the pipe has

occurred. Mr. Henley believes that concrete was dumped near the inlet of the spillway to alleviate this problem (see Photo 5). The joints of the pipe were also misaligned which indicates that voids have possibly been created under the pipe allowing differential settlement of the sections of pipe to occur. At the outlet end of the pipe, a concrete apron was constructed which extends out from the end of the pipe a distance of 2 feet. At the end of the concrete apron, flows through the pipe will drop into what appears to be the top portion of a buried 5-foot diameter steel drum (see Photo 6). The steel drum appears to act as a stilling basin. Beyond the steel drum, the discharge channel for the spillway is riprapped for the short distance it travels before intersecting the downstream channel just downstream of the dam. The outlet end of the pipe does not appear to be undermined.

(2) Siphon

The siphon was inoperable on the day of inspection due to the fact that the downstream portion of the siphon was cut off at the top of dam making it impossible for the siphon to operate. It was also noted that hand wheel operator for the gate valve was missing. According to Mr. Henley, at one time the siphon pipe did extend down the downstream slope to the toe and that the downstream portion of the pipe was removed by maintenance personnel to help facilitate the mowing of the downstream slope. Mr. Henley stated that he has access to a portable pump which can be used to level the reservoir instead of using the siphon.

e. Reservoir Area

The reservoir water surface elevation at the time of inspection was 688.3 feet above M.S.L.

The surface area of the reservoir at normal water level is about 10 acres. The rim seems to be stable as no severely eroded areas were observed. The land around the reservoir slopes gently to the rim and is grass and/or tree covered. There are no homes built in close proximity to the reservoir.

f. Downstream Channel

The downstream channel, which carries flows from the spillway, is a narrow gulley which crosses a golf course immediately below the dam. The channel is approximately 3 feet wide, 2 feet deep and has nearly vertical side slopes. Some erosion was observed on the sides of the channel. Outside of the small channel the floodplain widens out considerably (see Photo 8).

3.2 Evaluation

The visual inspection revealed the following condition that was felt to pose a threat to the safety of the dam and the spillway and would warrant prompt attention.

It appears that piping of embankment material has occurred in the past along the spillway pipe. This is indicated by the two large voids near the outlet of the spillway, a small depression on the downstream slope of the spillway pipe, several cracks on the upstream slope over the spillway pipe, and the misalignment of the joints of the spillway pipe. The stability of the spillway pipe appears to be in jeopardy due to this condition and if the condition is allowed to progress, it can only be detrimental to the stability of the dam and the spillway.

The following items were observed that are not sufficiently significant to indicate a need for immediate remedial action; however, they could adversely affect the dam in the future.

1. The wave erosion on the upstream slope does not appear to affect the stability of the dam in its present condition. However, continual erosion of the slope can only be detrimental to the stability of the dam.

2. The small shrubs on the upstream face growing in the wave eroded area should be properly maintained. Large vegetation could hinder a comprehensive inspection of the dam and allow potential problems to go undetected.

3. The rodent holes observed on the embankment could jeopardize the safety of the dam. The holes created by the animals make avenues for possible piping.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

There are no specific operational procedures which are followed at Stephens Lake Dam. When dry periods occur, water is pumped from the nearby well to keep the lake at a desired level.

4.2 Maintenance of Dam

The dam is maintained by workmen from the Buildings and Grounds Dept. of Stephens College. Mr. Marion Henley, Director of Buildings and Grounds, oversees the operation and maintenance of the lake and dam. At the time of inspection, the maintenance personnel were in the process of trying to trap the rodents which have burrowed into the embankment on the downstream slope. The top of dam and the embankment slopes are mowed regularly.

4.3 Maintenance of Operating Facilities

There are two operating facilities at the damsite. They are the vertical centrifugal turbine pump located on the south side of the reservoir and the siphon. The pump is maintained by personnel from the Buildings and Grounds Department of Stephens College. The siphon is inoperable.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any warning system in use at the damsite.

4.5 Evaluation

The maintenance for this dam is somewhat lacking. The corrective measures listed in Section 7 should be undertaken to improve the condition of the dam.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

No hydrologic and hydraulic design data are available for Stephens Lake Dam. The sizes of physical features utilized to develop the stage-outflow relation for the spillway and overtopping of the dam were prepared from field notes and sketches prepared during the field inspection. The reservoir elevation-area data were based on the U.S.G.S. Columbia, Missouri Quadrangle topographic maps (7.5 minute series). The spillway and overtop release rates and the reservoir elevation-area data are presented in Appendix B.

The hydrologic soil group of the watershed was determined from information available in the U.S.D.A. Soil Conservation Service publication "Missouri General Soil Map and Soil Association Descriptions", 1979. The Probable Maximum Precipitation (PMP) used to determine the Probable Maximum Flood (PMF) was determined by using the U.S. Weather Bureau publication, "Hydrometeorological Report No. 33" (April 1956). The 100-year flood was derived from 100-year rainfall of Jefferson City, Missouri, supplied by the St. Louis District of the Corps of Engineers.

b. Experience Data

It is believed that records of reservoir stage or spillway discharge are not maintained for this site. However, according to Mr. Henley, the maximum reservoir level was approximately 3-inches above the crest of the spillway.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1d and evaluated in Section 3.2.

d. Overtopping Potential

Both the Probable Maximum Flood and the half Probable Maximum Flood when routed through the reservoir, resulted in overtopping of the dam. The peak inflows for the PMF and one-half of the PMF are 887 cfs and 444 cfs, respectively. The peak outflow discharges for the PMF and one-half of the PMF are 616 and 50 cfs, respectively. The maximum capacity of the spillway just before overtopping the dam is 42 cfs. The PMF and one-half of the PMF overtopped the dam by 0.92 foot and 0.06 foot respectively. The total duration of flow over the dam is 4.33 hour and 1.58 hour for the PMF and the one-half of the PMF, respectively. Since the overtopping depth is only 0.06 feet during the occurrence of one-half of the PMF, the reservoir/spillway system of Stephens Lake Dam is considered capable of accommodating a flood equal to approximately ⁴⁵~~50~~ percent of the PMF just before overtopping the dam. The reservoir/spillway system of Stephens Lake Dam will accommodate the one-percent chance flood without overtopping. The surface soils in the embankment appear to be silty clay. The dam may be susceptible to erosion during overtopping.

The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life. The estimated damage zone extends approximately four miles downstream of the dam. There are thirteen dwellings, a trailer court, several apartment houses and commercial buildings within the damage zone.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no major signs of settlement or distress observed on the embankment or foundation during the visual inspection. The downstream slope of the embankment appears to be adequately protected from surface runoff erosion by a good grass cover. The erosion due to wave action on the upstream slope could affect the stability of the dam, if allowed to continue. There was no indication of past or present slope instability. In the absence of seepage and stability analyses, no quantitative evaluation of the structural stability can be made.

The stability of the spillway pipe appears to be questionable due to the misalignment of the joints, which appears to be due to the possible past piping of embankment material along the perimeter of the pipe, as described in Section 3.2. This condition, if allowed to worsen, will not only jeopardize the stability of the spillway further but will also jeopardize the stability of the dam.

b. Design and Construction Data

No design computations were uncovered during the report preparation phase. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters were available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction were available for use in a stability analysis.

c. Operating Records

No operating records were available relating to the dam or appurtenant structures. The water level on the day of the visual inspection was approximately 8 inches below the spillway crest. The normal operating level is considered to be at the spillway crest. According to Mr. Henley, the highest water level in the lake was approximately 3 inches above the spillway crest.

d. Post Construction Changes

According to Mr. Henley, two post construction changes have been made to the embankment since the original construction. The height of the dam was increased in 1939 to increase the reservoir capacity, and the existing spillway structure was installed in 1955 along the left side of the dam. It is unknown what effect these post construction changes had on the stability of the dam, if any.

e. Seismic Stability

The dam is located in Seismic Zone 1, as defined in "Recommended Guidelines for Safety Inspection of Dams" prepared by the Corps of Engineers, and will not require a seismic stability analysis. An earthquake of the magnitude which would be expected in Seismic Zone 1 will not cause distress to a well designed and constructed earth dam. Available literature indicates that no active faults exist near the vicinity of the damsite.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspection. Detailed investigations, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based upon observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to note that the condition of a dam depends upon numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be assurance that an unsafe condition could be detected.

a. Safety

The dam appears to be in fair physical condition due to the evidence of past piping of embankment materials along the spillway pipe. Also, the spillway capacity of Stephens Lake Dam is found to be "Inadequate". The spillway/reservoir system will accommodate approximately ⁴⁶~~50~~ percent of the PMF without overtopping the dam. The surface soils in the embankment appears to be silty clay. The dam embankment has a good grass cover. The dam is overtopped by 0.92 feet during the occurrence of the PMF. The dam may be susceptible to erosion due to overtopping of the dam during the PMF.

A quantitative evaluation of the safety of the embankment could not be made in view of the absence of seepage and stability analyses. The present embankment and appurtenant structures, however, reportedly have performed satisfactorily since their construction; there have been no failures. Reportedly, the dam has never been overtopped and no evidence indicating the contrary was observed. The safety of the dam can be improved if the deficiencies described in Section 3.2 and 6.1a are properly corrected as described in Section 7.2.

b. Adequacy of Information

The conclusions presented in this report are based upon field measurement, past performance and the present condition of the dam. Information on the design hydrology and hydraulic design of the dam was not available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency

The items recommended in paragraph 7.2a and the first item in paragraph 7.2b should be pursued on a high priority basis. The remaining remedial measures recommended in Paragraph 7.2 should be accomplished within a reasonable period of time.

d. Necessity for Phase II Inspection

Based upon results of the Phase I inspection, a Phase II inspection is not felt to be necessary.

7.2

Remedial Measures

a. Alternatives

One of the following mitigation measures should be undertaken under the guidance of an engineer experienced in the design and construction of earth dams to avoid severe consequences of dam failure from overtopping.

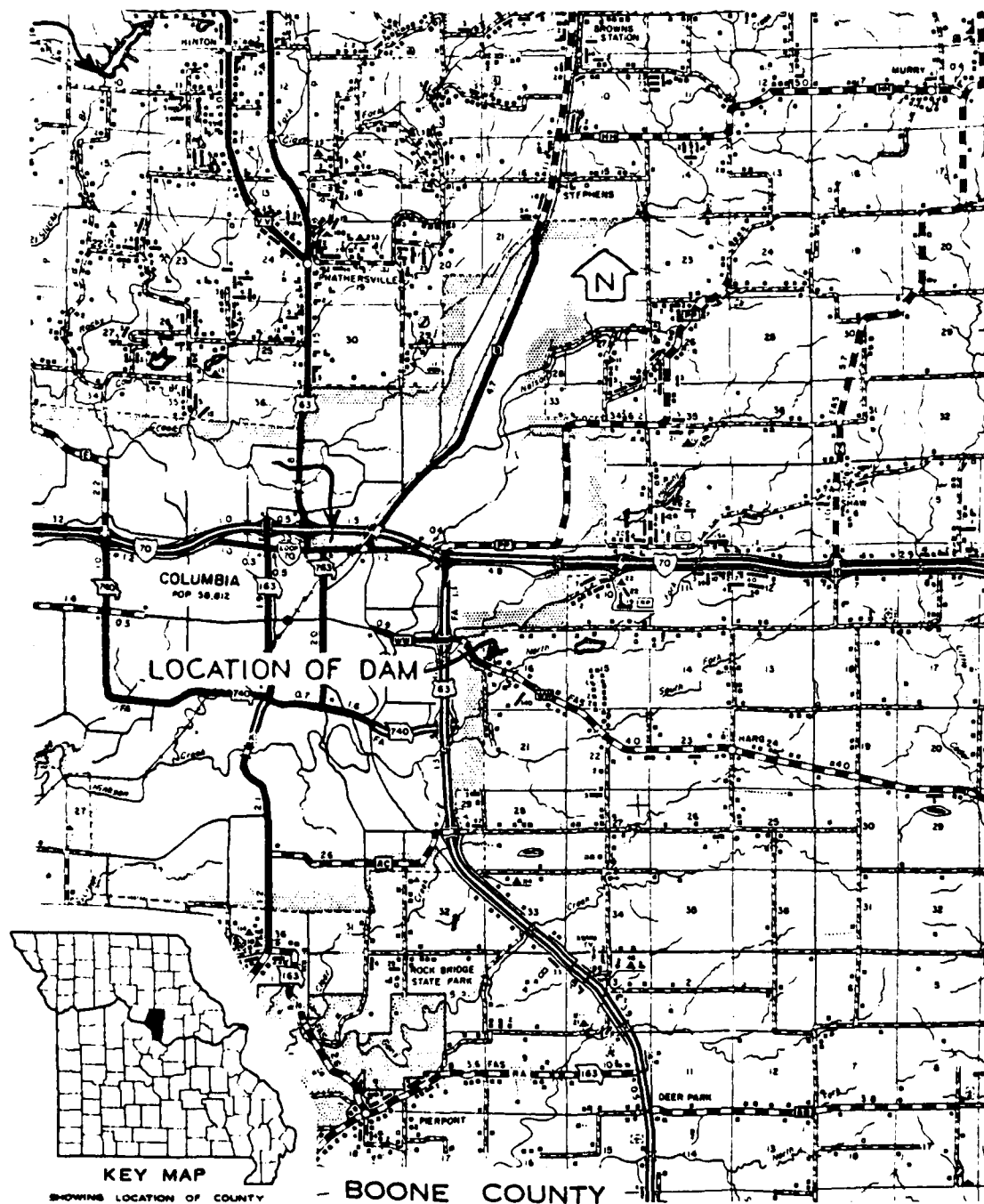
1. Increase the spillway capacity to pass the PMF without overtopping the dam.
2. Increase the height of the dam enough to pass the PMF without overtopping the dam; an investigation should also be done which includes studying the effects on the structural stability of the existing embankment. The overtopping depth during the occurrence of the PMF, stated in Section 5.1d, is not the required or recommended increase in the height of the dam.
3. A combination of 1 and 2 above.
4. Provide a highly reliable flood warning system (generally does not prevent damage but avoids loss of life).

b. O & M Procedures

1. Further investigation should be undertaken to determine if indeed past piping of the embankment material has occurred along the spillway pipe. Measures should then be undertaken to control the condition and proper repairs made to correct the damages that have already occurred to the dam and the spillway. The investigation should be carried out under the direction of a qualified professional engineer.

2. The erosion due to wave action on the upstream slope should be properly repaired and adequately protected from further damage.
3. The small shrubs which are growing on the eroded area should be cleared from the embankment and prevented from growing back.
4. Determine the extent of damage done to the embankment by burrowing animals, if any, and make corrective repairs as required. All burrowing animals should be eliminated from the embankment and their burrows properly backfilled and compacted.
5. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.
6. The owner should initiate the following programs:
 - (a) Periodic inspection of the dam by a professional engineer experienced in the design and construction of earth dams.
 - (b) Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

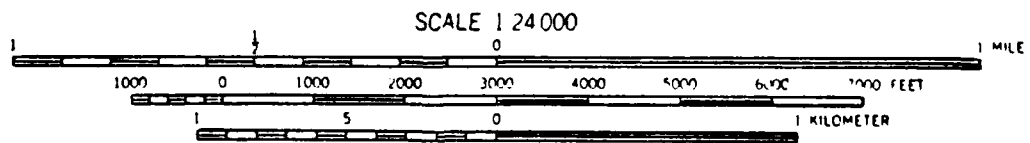
PLATES



LOCATION MAP - STEPHENS LAKE DAM

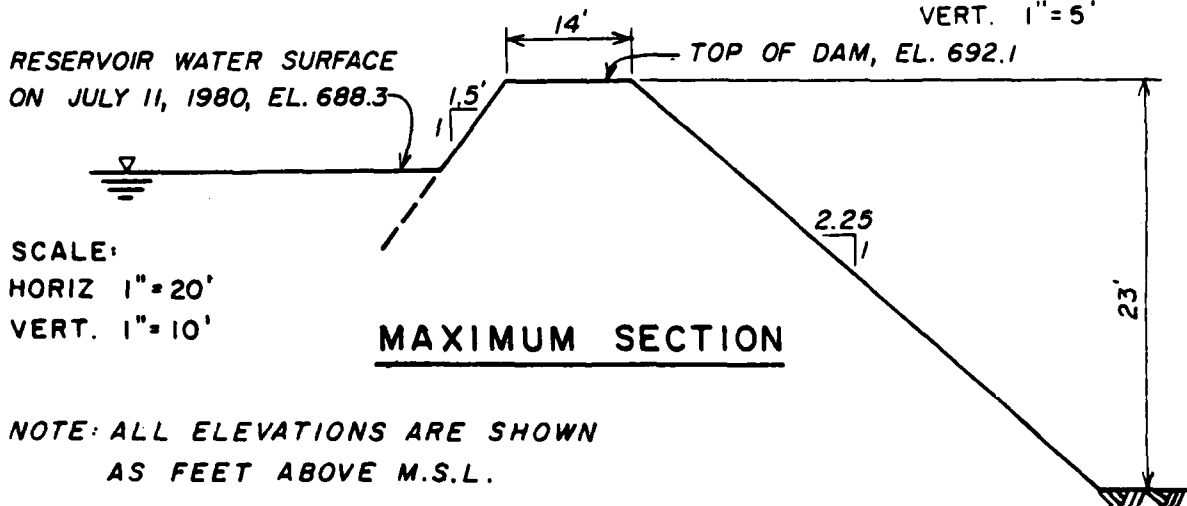
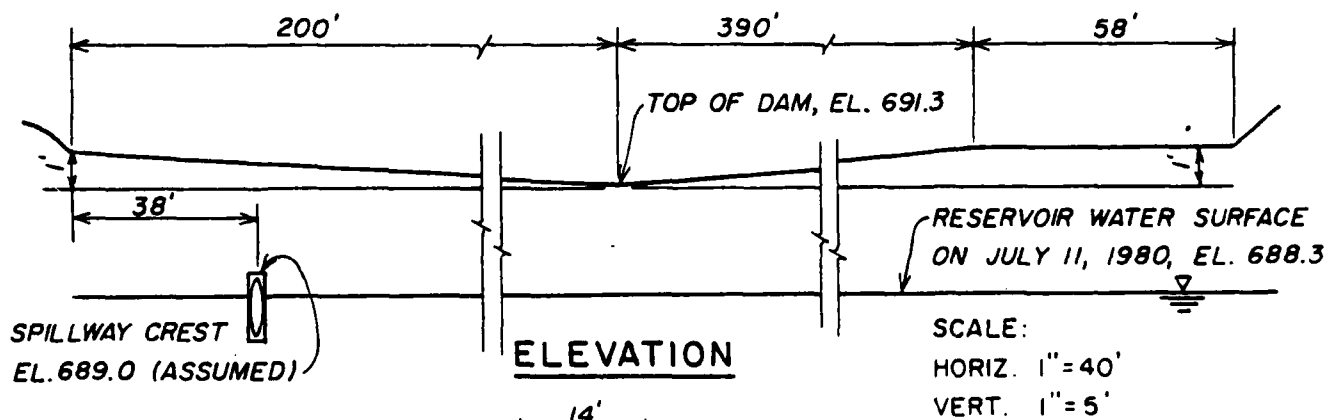
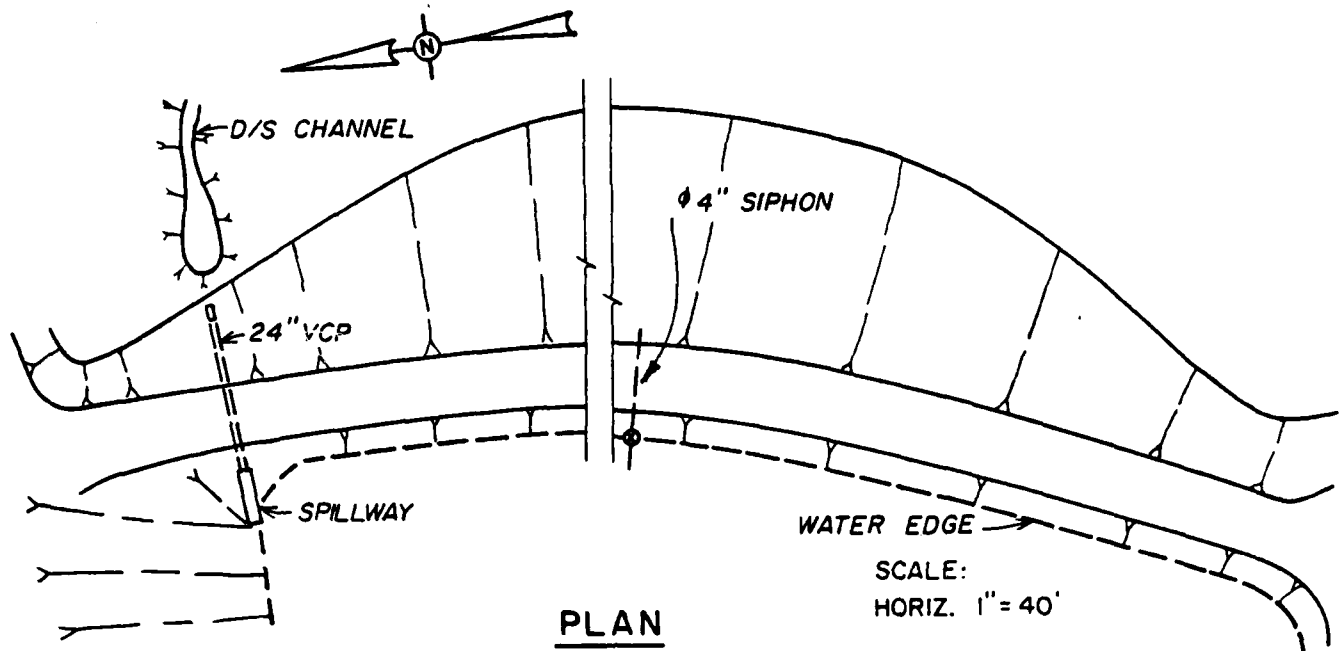
MO-11172

PLATE 1A

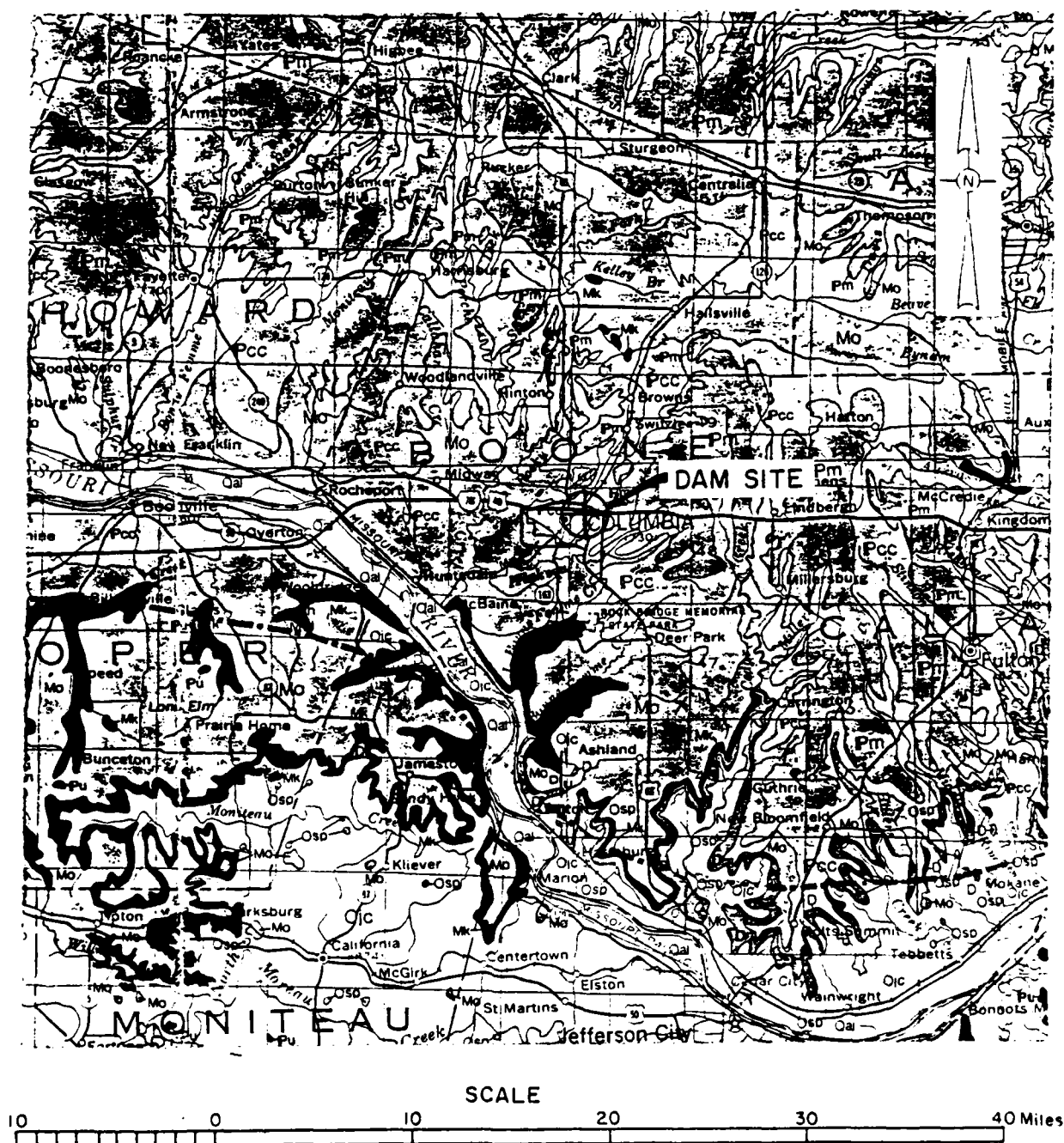


CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

STEPHENS LAKE DAM (MO. 1117?)
DRAINAGE BASIN AND
DOWNSTREAM HAZARD ZONE



STEPHENS LAKE DAM (MO. 11172)
PLAN, ELEVATION &
MAXIMUM SECTION OF EMBANKMENT



⊕ LOCATION OF DAM

NOTE: LEGEND OF THIS DAM IS ON PLATE 4

REFERENCE:

GEOLOGIC MAP OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI GEOLOGICAL SURVEY
KENNETH H. ANDERSON, 1979

REGIONAL GEOLOGICAL MAP
OF
STEPHENS LAKE DAM

LEGEND

<u>PERIOD</u>	<u>SYMBOL</u>	<u>DESCRIPTION</u>
QUATERNARY	Qal	ALLUVIUM: SAND, SILT, GRAVEL
PENNSYLVANIAN	Pu	PENNSYLVANIAN UNDIFFERENTIATED
	Pm	MARMATON GROUP: CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
	Pcc	CHEROKEE GROUP: CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
MISSISSIPPIAN	Mo	KEOKUK - BURLINGTON FORMATION: CHERTY GRAYISH BROWN SANDY LIMESTONE
	Mk	CHOUTEAU GROUP: NORTHVIEW AND BACHELOR FORMATION (LIMESTONE AND SHALE)
DEVONIAN	D	SULPHUR SPRING GROUP: GLEN PARK LIMESTONE AND GRASSY CREEK SHALE
ORDOVICIAN	Osp	ST PETER SANDSTONE
	Ojc.	SMITHVILLE FORMATION POWELL DOLOMITE

APPENDIX A

PHOTOGRAPHS

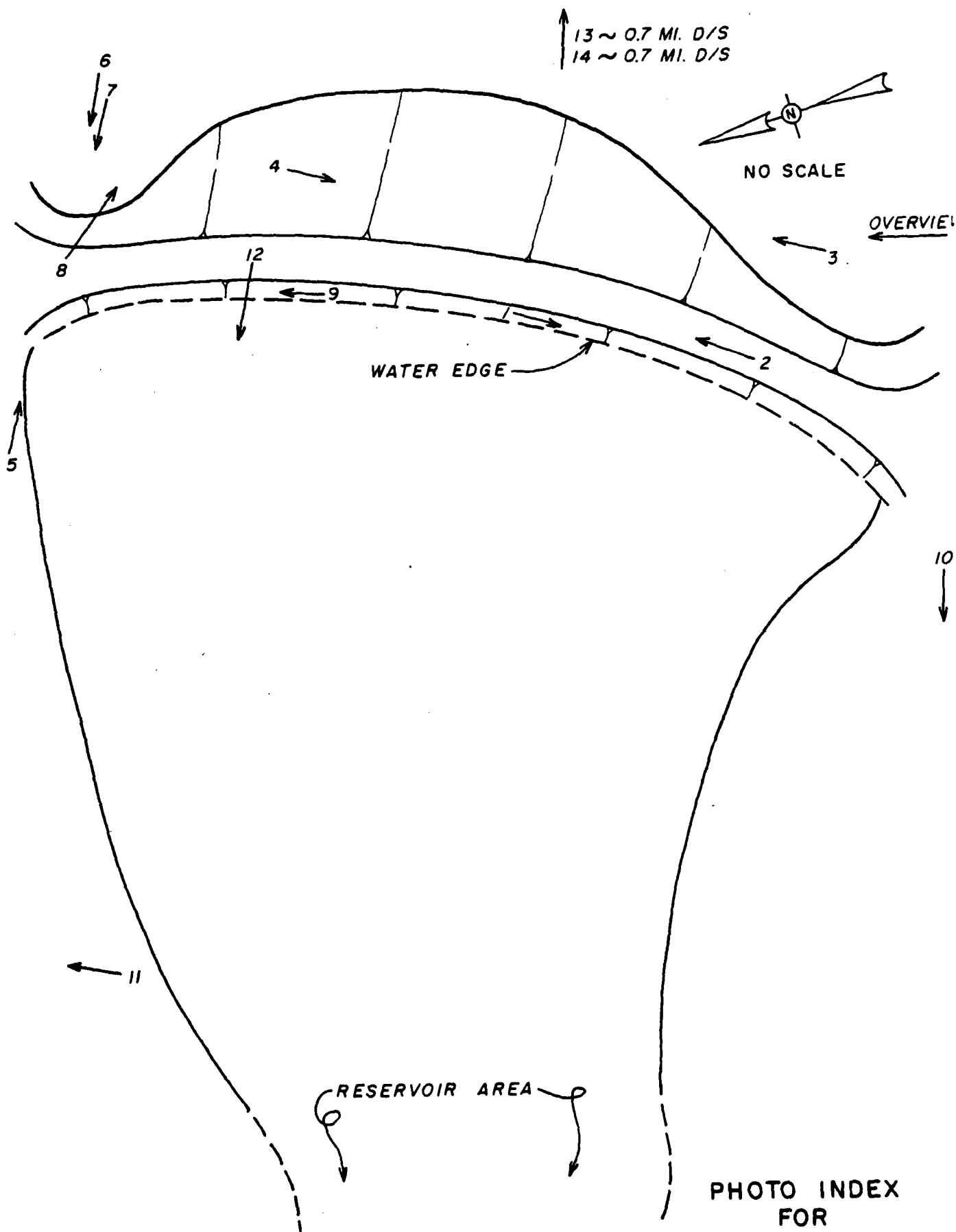


PHOTO INDEX
FOR
STEPHENS LAKE DAM

Stephens Lake Dam

Photographs

- Photo 1 - View of the upstream slope showing vegetative cover and riprap. Note the batter boards holding the riprap in place.
- Photo 2 - View of the top of dam.
- Photo 3 - View of the downstream slope.
- Photo 4 - View of a rodent hole on the downstream slope.
- Photo 5 - View of the concrete side channel structure and the inlet to the clay pipe. Note the dumped concrete to the right of the side channel.
- Photo 6 - View of the outlet of the clay pipe showing the concrete apron, the 5-foot diameter steel drum and the riprap in the discharge channel. Note the depression on the slope behind and to the left (in photo) of the outlet.
- Photo 7 - Close-up view of the depression in Photo 6 showing erosion of the embankment material along the spillway outlet pipe.
- Photo 8 - View of the downstream channel from the left abutment.
- Photo 9 - View of the 4-inch siphon on the upstream slope.
- Photo 10 - View of the vertical centrifugal turbine pump located on the right side of the reservoir rim.

- Photo 11 - View of the limestone outcrop on the northeast side of the reservoir.
- Photo 12 - View of the reservoir and rim.
- Photo 13 - View of a dwelling downstream of the dam that appears to be in the downstream hazard zone.
- Photo 14 - View of a dwelling downstream of the dam that appears to be in the downstream hazard zone.

Stephens Lake Dam



Photo 1



Photo 2

Stephens Lake Dam

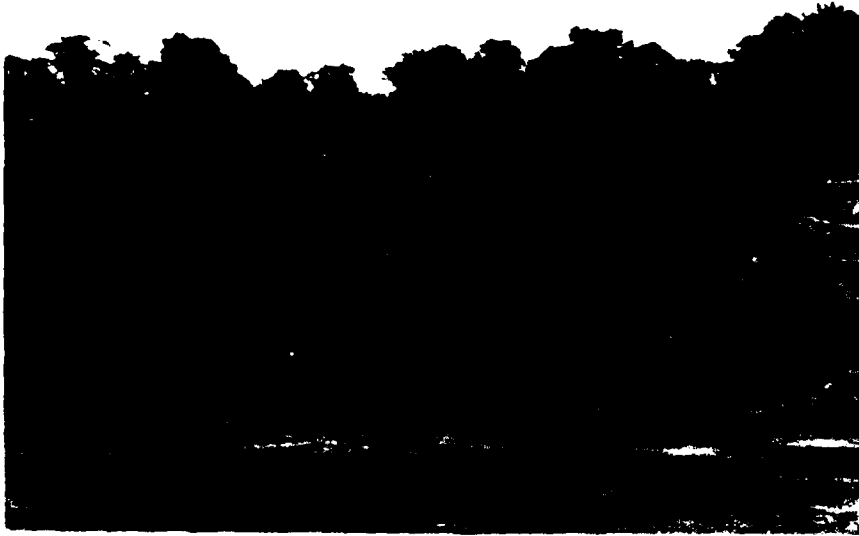


Photo 3

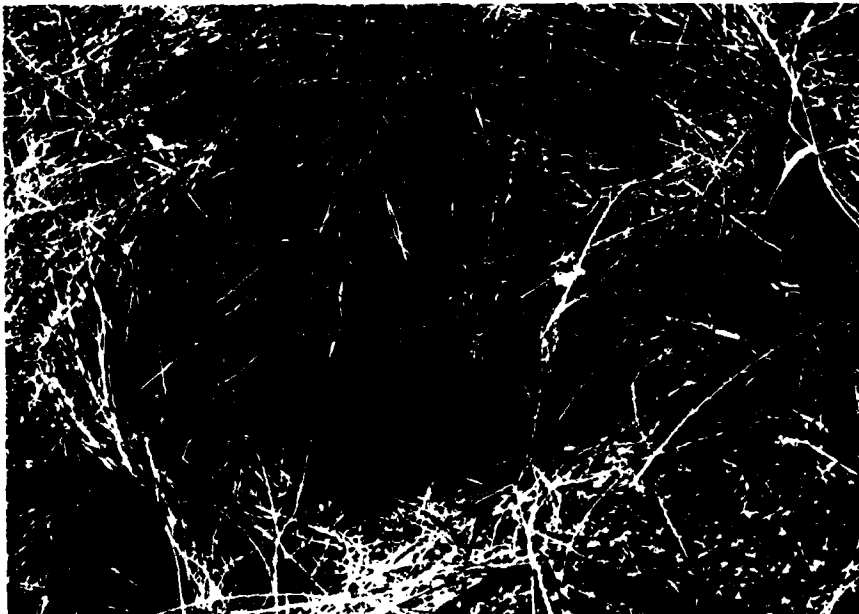


Photo 4

Stephens Lake Dam



Photo 5



Photo 6

Stephens Lake Dam



Photo 7



Photo 8

Stephens Lake Dam



Photo 9



Photo 10

Stephens Lake Dam

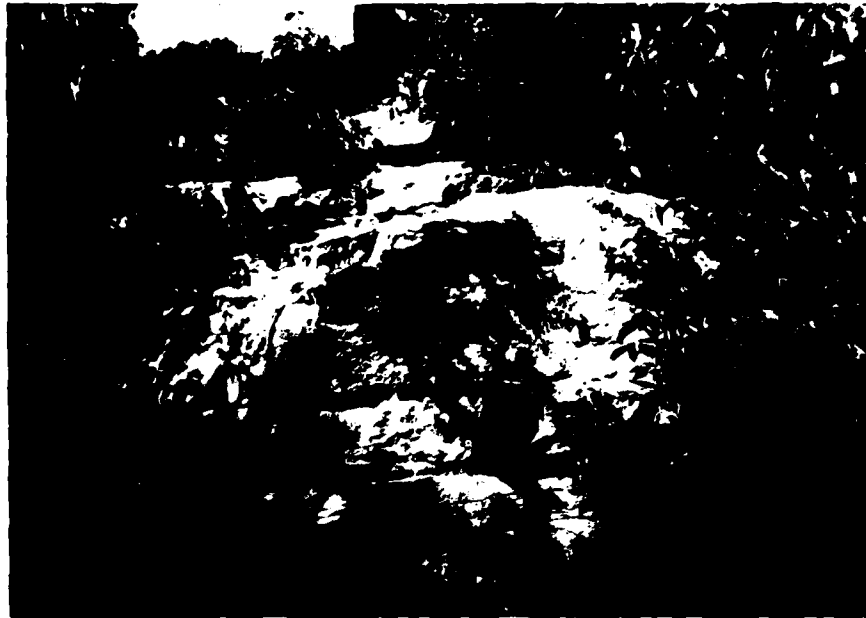


Photo 11



Photo 12

Stephens Lake Dam



Photo 13

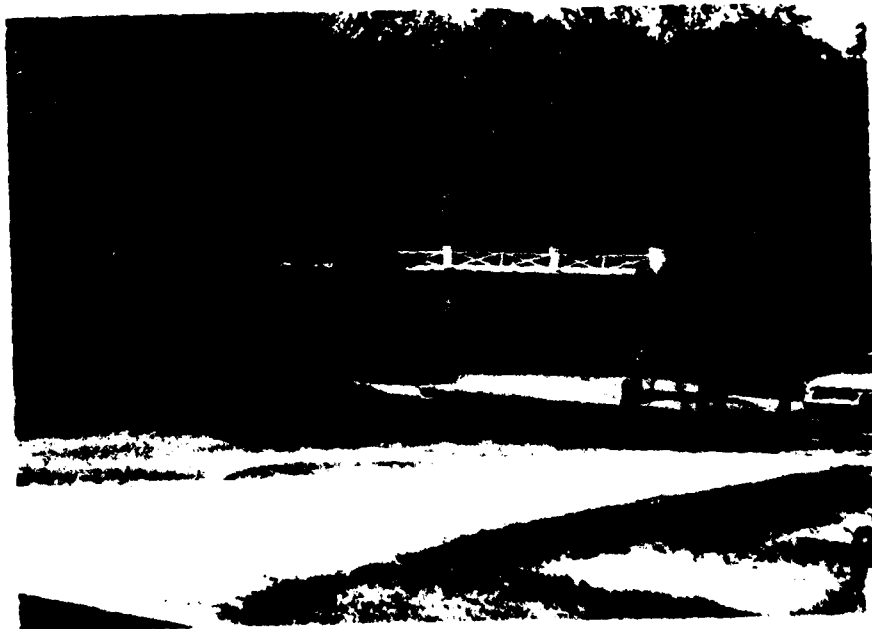


Photo 14

APPENDIX B

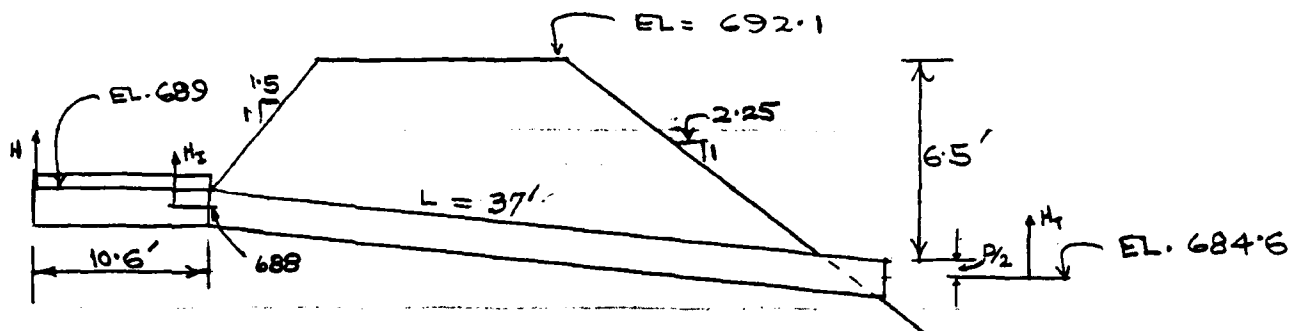
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

STEPHENS LAKE DAM

HYDROLOGIC AND HYDRAULIC DATA, ASSUMPTIONS AND METHODOLOGY

1. SCS Unit Hydrograph and HEC-1DB are used to develop the inflow hydrographs, and the hydrologic inputs are as follows:
 - (a) Twenty-four hour probable maximum precipitation from Hydro-meteorological Report No. 33, and 100-year 24-hour rainfall of Jefferson City, Missouri.
 - (b) Drainage area = 38 acres.
 - (c) Lag time = 0.07 hour.
 - (d) Hydrologic Soil Group:
Soil Group "C"
 - (e) Runoff curve number:
CN = 80 for AMC II and CN = 91 for AMC III.
2. Spillway release rates are based on weir, orifice, and pressure flow depending on the stage of the reservoir. Flow rates over the dam are based on broad crested weir equation $Q = CLH^{3/2}$ and critical depth assumption.
3. Floods are routed through Stephens Lake to determine the capability of its spillway.

DAM SAFETY INSPECTION / MISSOURI-1980 SHEET NO. 1 OF 4
 STEPHENS LAKE DAM (MO. 11172) JOB NO. 1263
 SPILLWAY DISCHARGE COMPUTATIONS BY MAS DATE 8/27/87



Weir Flow:

$$Q = CLH^{1.5}, \quad C = 3.0$$

$$L = 10.6'$$

$$H = \text{W.S. EL.} - 689$$

$$Q = 3.0 (10.6) (H)^{1.5}$$

$$Q = 31.80 (H)^{1.5}$$

Orifice Flow:

$$Q = CA \sqrt{2gH_x}, \quad C = 0.84$$

$$A = \pi$$

$$H_x = \text{W.S. EL.} - 688$$

$$Q = 0.84 (\pi) \sqrt{2gH_x}$$

$$Q = 21.18 \sqrt{H_x}$$

Pressure Flow:

$$Q = A \sqrt{\frac{2g}{\Sigma K} H_T}, \quad A = \pi$$

$\Sigma K = (K_{\text{entrance}} + K_{\text{friction}} + K_{\text{exit}})$, where

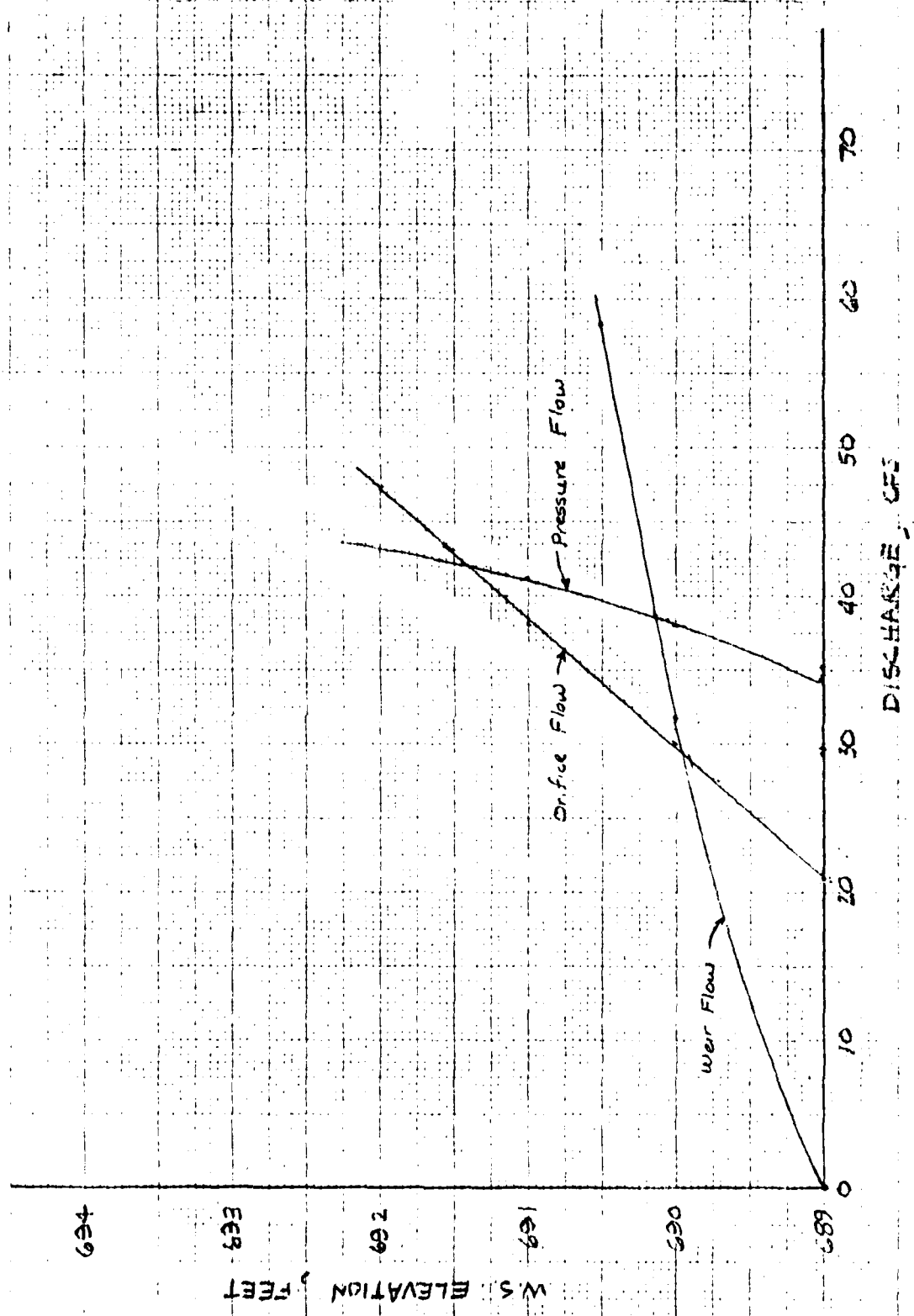
$$K_{\text{entrance}} = 0.5$$

$$K_{\text{friction}} = 29.16 \frac{n^2 L}{(R_H)^{4/3}} = 29.16 \frac{(0.018)^2 (37')}{(0.5)^{4/3}} = 0.88$$

$$K_{\text{exit}} = 1.0$$

$$\Sigma K = 2.38$$

$$Q = \pi \sqrt{2g/2.38} H_T = 16.34 \sqrt{H_T} \quad H_T = \text{W.S. EL.} - 684.6$$



STEPHENS LAKE DAM (MO 11172)
SERVICE SPILLWAY RATING CURVE

DAM SAFETY INSPECTION - MISSOURI

SHEET NO. 3 OF 4

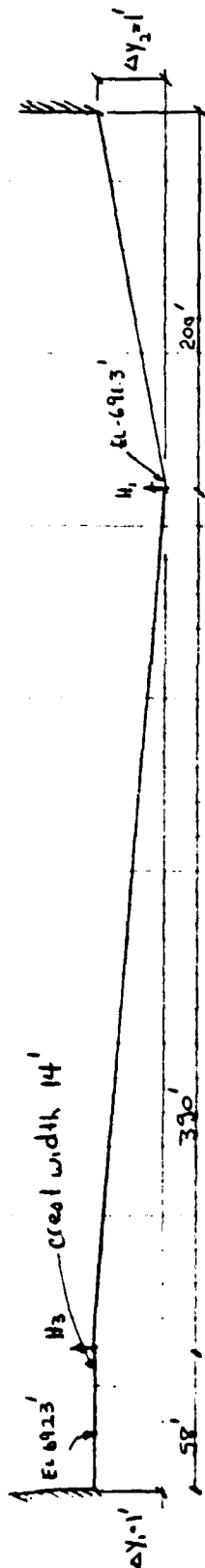
STEPHENS LAKE DAM (No 1172)

JOB NO. 1263

OVERTOP RATING CURVE

BY D.C. DATE 7/27/80
H1B

KL 32



H.	$\chi^2_{(n-2)} / (n-2)$	T_1	A_1	$Q \cdot \sqrt{\frac{A_1^2}{T_1}}$	$\chi^2_{(n-2)} / (n-2)$	T_2	A_2	$Q \cdot \sqrt{\frac{A_2^2}{T_2}}$	C_3	L_3	H_3	$Q_3 \cdot C_3 \cdot L_3$	$Q_3 + Q_1 + Q_2$	WSE L
.3	.24	93.6	11.23	2.08	.24	48	576	1.32					33	691.3
.7	.56	218.4	61.15	12.62	.56	112	3136	4.16					278	692.0
1.0	.80	312.0	124.8	17.89	.80	160	64	29.69					678	692.3
1.3	1.03	330	208.0	81.97	1.03	200	10667	42.03	2.99	58	.3	28.48	1332	692.6
1.7	1.30	390	312.0	153.5	1.30	200	160	82.07	3.03	58	.7	102.91	2498	693.0
2.2	1.63	390	442.0	220.1	1.63	200	2260	139.3	3.04	58	1.2	23.61	4271	693.5
2.7	1.97	390	572.0	330.9	1.97	200	293.3	205.8	3.04	58	1.7	39.21	6339	694.0
3.0	2.17	390	650.0	411.7	2.17	200	333.3	241.7	3.05	58	2.0	49.62	7703	694.3
3.4	2.43	390	754.0	519.12	2.43	200	386.7	350.8	3.06	58	2.4	65.79	9660	694.7
3.7	2.63	390	832.0	605.7	2.63	200	428.7	386.3	3.07	58	2.7	78.24	11221	695.0

PRC ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION / MISSOURI - 1980

SHEET NO. 4 OF 4

STEPHENS LAKE DAM (MO. 11172)

JOB NO. 1263

SPILLWAY AND OVERTOP RATING CURVE

BY JFK DATE 9/2/80

W.S. ELEV.	Q SERVICE SPILLWAY	Q OVERTOP	Q COMBINED
689	0		0
690	31.8 *		31.8
691	36.7 **		36.7
691.3	42.3 ***	0	42.3
691.6	43.2	33	76
692	44.5	278	323
692.3	45.3	678	723
692.6	46.2	1332	1378
693	47.4	2498	2546
693.5	48.8	4271	4320
694	50.1	6338	6388
694.3	50.9	7703	7754
694.7	51.9	9660	9712
695	52.7	11221	11274

* Weir flow controls

** Orifice flow controls

*** Pressure flow controls at EL = 691.3 and above

DAM SAFETY INSPECTION / MISSOURI

SHEET NO. 1 OF 1

DAM NAME: STEPHENS LAKE DAM (MO 11172)

JOB NO. 1263

UNIT HYDROGRAPH PARAMETERS

BY D.C. DATE 7/24/80

- 1) DRAINAGE AREA, $A = .059$ sq. mi. = (38.0 acres)
- 2) LENGTH OF STREAM, $L = (.75' \times 2000' = 1500') = .284$ mi.
- 3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,
 $H_1 = 777'$
- 4) ELEVATION OF RESERVOIR AT SPILLWAY CREST, $H_2 = 689'$
- 5) ELEVATION OF CHANNEL BED AT $0.85L$, $E_{85} = 768'$
- 6) ELEVATION OF CHANNEL BED AT $0.10L$, $E_{10} = 698'$
- 7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10}) / 0.75L = .062$
- 8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$$t_c = [(11.9 \times L^3) / (H_1 - H_2)]^{0.385} = \left[\frac{11.9 (.284)^3}{777 - 689} \right]^{0.385} = .11$$

B) BY VELOCITY ESTIMATE,

$$SLOPE = 6.2\% \Rightarrow \text{AVG. VELOCITY} = 5 \text{ fps}$$

$$t_c = L / V = 1500 / 5 (3600) = .083$$

USE $t_c = .11$

$$9) \text{ LAG TIME, } t_L = 0.6 t_c = .066 \approx .07$$

$$10) \text{ UNIT DURATION, } D \leq t_L / 3 = .022$$

< 0.083 hr.

USE $D = .083$

$$11) \text{ TIME TO PEAK, } T_p = D/2 + t_L = .107$$

12) PEAK DISCHARGE,

$$q_p = (484 \times A) / T_p = 266 \text{ cfs}$$

DAM SAFETY INSPECTION

SHEET NO. _____ OF _____

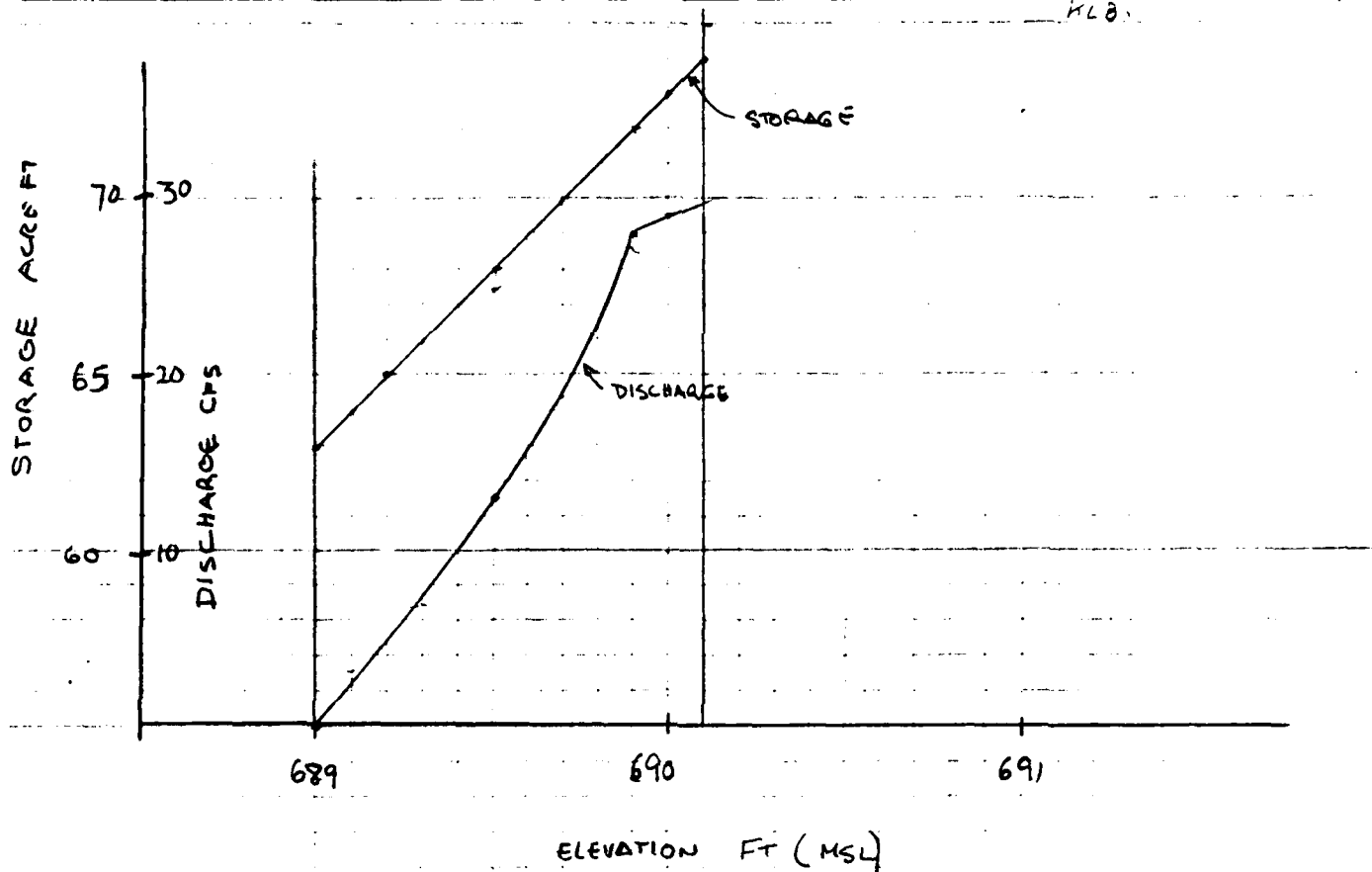
STEPHENS LAKE DAM (MO 11172)

JOB NO. 1263

STARTING WSEL FOR PMF ROUTING

BY DC DATE 7/30/80

HLS



From 690.1 - 689.5

$$\Delta S = 74 - 68 = 6 \text{ acre-ft}$$

$$Q_m = 22 \text{ cfs}$$

$$\Delta t = 6 \text{ acre-ft} \times \frac{43560 \text{ ft}^2}{\text{acre}} \times \frac{1 \text{ s}}{22 \text{ ft}^3} \times \frac{1 \text{ day}}{86400 \text{ s}} = .1375$$

From 689.5 - 689

$$\Delta S = 68 - 63 = 5 \text{ acre-ft}$$

$$Q_m = 7 \text{ cfs}$$

$$\Delta t = .36 \text{ days}$$

$$\text{total time} = .1375 + .36 \approx .5 \text{ days} < 3 \text{ days}$$

∴ Start PMF routing at spillway crest

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79

1	1	DAM SAFETY INSPECTION MISSOURI							
2	A2	STEPHENS LAKE DAM (MO 11172)							
3	A3	PMF AND 50 PERCENT PMF							
4	3	300	9	5	0	0	0	0	0
5	4	5							
6	5	1	2	1					
7	6	1	.5						
8	7	MO11172							
9	8	INPUT PRECIPITATION INDEX, RATIOS, AND UNIT HYDROGRAPH PARAMETERS							
10	9	1	2	.059	1				1
11	10		24.8	100	120	130			
12	11						-1	-91	
13	12		.67						
14	13			1					
15	14	1 MO11172							
16	15	ROUTE HYDROGRAPH THROUGH STEPHENS LAKE DAM (MO 11172)							
17	16				1				
18	17	1					-589	-1	
19	18	1	690	591	591.3	591.6	590	590.3	593
20	19	694	694.3	694.7	695				693.5
21	20		31.8	36.7	42.3	76	323	723	2546
22	21	6368	7754	5712	11274				4320
23	22		10	11	12	10.5	19		
24	23	670	609	590	591.3	700	710		
25	24	689							
26	25	691.3							
27	26	99							

FLOOD HYDROGRAPH PACKAGE INTER-11
DAM SAFETY VERSION JULY 1976
LAST MODIFICATION 126 FEB 79

RUN DATE 08/09/82
TIME 05:00:00

DAM SAFETY INSPECTION MISSOURI
TRIPPER'S LAKE-DAM AND TAILRAT
SNAP AND 50 PERCENT PPG

JOB SPECIFICATION
NO MHR MIN IDAY INH ININ METRC IPT IPT NSTAN
300 0 0 0 0 0 0 0 0 0 0 0

MULTI-PLAN ANALYSES TO BE PERFORMED
PLANES 1 NPTIO= 2 LRTIO= 1
WIDE= 1.00 7.00

SUB-AREA RUNOFF COMPUTATION
INPUT PRECIPITATION INDEX, RATIOS, AND UNIT HYDROGRAPH PARAMETERS

ISTAO ICOMP ICEON ITAPE JPLT JPT INAM IESTAGE IAUTO
011172 0 0 0 0 0 0 0 0 0 0 0

HYDRO LONG AREA SNAP IRSDA TRSPC RATIO ISNOU ISAME LOCAL
2 .00 0.00 .00 1.00 0.00 0.00 0.00 0.00 0.00 0.00

PRECIP DATA
R12 R24 R48 R72 R96
0.00 0.00 100.00 120.00 130.00 0.00 0.00 0.00 0.00

LOSS DATA
LROPT STRR DLTKR RTLOL GRAIN STKRS RTION STRIL CNSTL ALSMA RTIMP
0.00 0.00 0.00 1.00 0.00 0.00 1.00 -1.00 -91.00 0.00 0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .07
RECESSION DATA
STRIDE 0.00 ORCSN= 0.00 RTIOR= 1.00
TIME INCREMENT TOO LARGE--INIO IS BY LAG/2
UNIT HYDROGRAPH 6 END OF PERIOD ORDINATES: TC= 0.00 HOURS, LAG= .07 VOL= 1.00

28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236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DEPOSITION	SILVER	PLAY	HARIO	JAYJO	RATINGS APPLIED TO FLOWS
		AREA			
			1.00		
				.50	

DESCRIPTION	DATE	AMOUNT	BALANCE
HYDROGRAPH AT 011172	04	497.	497.
	159	25.12	12.56
ROUTED TO	05	615.	60.
	159	17.88	1.00

SUM 32.24 31.04 1-15 1415.
(815.14 790.34 27.94 121.11)

HYDROGRAPH ROUTING

ROUT. HYDROGRAPH THROUGH STEPHENS LAKE DAM (NO 1172)

DATE	TIME	INCOM	ITIME	JPLY	JERY	INIMP	ITIMSE	TAUTO
011172	1	0	0	0	0	1	0	0

ROUTING DATA

DATE	TIME	INCOM	ITIME	JPLY	JERY	INIMP	ITIMSE	TAUTO
011172	1	0	0	0	0	1	0	0

ROUTING DATA

DATE	TIME	INCOM	ITIME	JPLY	JERY	INIMP	ITIMSE	TAUTO
011172	1	0	0	0	0	1	0	0

ROUTING DATA

DATE	TIME	INCOM	ITIME	JPLY	JERY	INIMP	ITIMSE	TAUTO
011172	1	0	0	0	0	1	0	0

ROUTING DATA

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011172	1	0	0	0	0	1	0	0

ROUTING DATA

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ROUTING DATA

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ROUTING DATA

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011172	1	0	0	0	0	1	0	0

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011172	1	0	0	0	0	1	0	0

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DATE	TIME	INCOM	ITIME	JPLY	JERY	INIMP	ITIMSE	TAUTO
011172	1	0	0	0	0	1	0	0

ROUTING DATA

DATE	TIME	INCOM	ITIME	JPLY	JERY	INIMP	ITIMSE	TAUTO
011172	1	0	0	0	0	1	0	0

RESERVOIR AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLANS. DATE: ESTIMATED CONCENTRATIONS
 FLOW IN CUBIC FEET PER SECOND (CFS) (METERS PER SECOND)
 DATA IN SQUARE MILES (SQ MI) (KILOMETERS)

DIRECTION STATION AREA PLAN DATE 1 RATIO 2 RATIO 3 RATIOS APPLIED TO FLOWS
 .40 .45 .50

HYDROGRAPH AT 011172
 .06 1 355 398 446
 .15 13,050 11,300 12,600

ROUTED TO 011172
 .06 1 36 40 50
 .15 1.020 1.100 1.400

